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EFFECT OF IRRIGATION ON AGRONOMIC TRAITS OF WHEAT (*TRITICUM AESTIVUM* L.)

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ABSTRACT

The effect of nine different levels of irrigation on yield and yield components of wheat indicated that Uqab-2000 gave 7.0% to 8.8% higher total dry matter yield than Chenab-2000 in 2001-2002 and in 2002-2003, respectively. Crop was irrigated partially or fully i.e. throughout the season including grain growth period increased grain yield by 136.1% due to an increase in the number of ears m^{-2}, number of spikelts per ear over unirrigated plants.Irrigation increased the number of grains $spike^{-1}$ over unirrigated treatment by 46-66 % in different seasons. Cultivar differences in mean grain weight were non-significant in both the years.Moisture stress during grain growth period drastically reduced the mean grain weight.The fully irrigated treatments increased mean grain weight by 104.5% in 2001-2002 and 22.0% in 2002-2003 over unirrigated control treatment. Mean harvest index varied from 29.63 % to 31.0%. There was a positive and linear relationship between total dry matter and grain yield.

Key words: Irrigation , dry matter, wheat, agronomy,

INTRODUCTION

Wheat (*Triticum aestivum* L.) is grown in Pakistan on an area of 8069 thousand hectares, with an annual production of 19235 thousand tons and having an average yield of 2384kg ha^{-1} (GOP, 2003). Irrigation has been shown to increase crop yield in arid and semi arid climates (Hussain *et al.*, 2004). The highest total dry matter (TDM) and grain yields were obtained from fully irrigated treatments due to more number of tillers; heavy and more number of grains per unit area. Drought imposed throughout or early in the season depressed RUE significantly by 11-33 % compared with the fully irrigation treatment and thus ultimately the crop yield (Sajjad, 2001). Availability of soil moisture influences many aspects of crop growth and yield.High growth (LAI, LAD) of wheat is due to more light interception during the season (Sharif, 1999). Qadir *et al.* (1999) concluded that moisture stress during vegetative and at reproductive growth stages caused reduction in LAI and also the number of fertile tillers per unit area, grains per spike and 1000-grain weight, thus reduction in the final grain yield of the crop. Cortazar *et al.* (1995) concluded that drought reduced leaf area, total dry matter and increased the number of dry leaves. Swati *et al.* (1985) reported that any increase in the number of irrigations was equally associated with an increase in yield and yield components. Spike length, 1000-grain weight and grain yield per unit area significantly increased in all combinations of irrigation over no irrigation. Bajwa *et al.* (1993) reported that after three year research work on two varieties of wheat viz. Faialabad-83 and Punjab-85 by varying irrigation at different stages that grain yield, tillering m^{-1} row and 1000-grain weight was found the highest in fully irrigated treatments; whereas grains $spike^{-1}$ had been significantly different during the third year. The number of tillers m^{-1} row had been significantly higher in those treatments where irrigation had been applied at crown root stage than the other where the irrigation at crown root stage had been missed. The highest grain yield had been recorded in T_6 (crown root + boot + grain filling + dough stage) followed by T_5 (crown root + boot + grain filling) and T_4 (crown root + boot) but statistically these had been at par. Reddi and Reddi (1995) described that moisture stress at flowering stage reduced the number of grains ear^{-1}, and stress at grain filling stage resulted in low grain weight and shriveled seed. Lack of adequate moisture during tillering, jointing, pre-flowering and milk stages reduced ear number, number of grains per ear and mean grain weight.Kuixiang *et al.* (1994) reported that when wheat irrigated with 0, 1200, or 2400 m^3 water ha^{-1}, grain yields increased with increased irrigation. Hussain *et al.* (1997) investigated that grain yield of irrigated crop was 5.13 and 6.31 t ha^{-1} in 1989-90 and 1992-93, respectively; about 80% higher than the yield of un-irrigated crop. The increase in yield due to irrigation was mainly associated with an increase in total dry matter production. Wajid (2004) revealed that both the cultivars and irrigation treatments significantly affected the number of tillers m^{-2}. Number of spike-lets per spike were non significant during 1998-99 but were significant during 1999-2000 for the cultivars. Nonetheless, irrigation treatments significantly enhanced the number of spikelets per spike over control treatments by 25.13 % to 33.13 %. The number of grains per ear for cultivars did not differ significantly during 1998-99 but it was significantly different during 1999-2000. Irrigation treatments showed higher number of grains per spike over control in both the seasons. Similarly cultivar differences in mean grain weight were significant only during 1999-2000 when Inqalab-91 gave16.87 % (38.66 g vs. 33.8 g) more grain weight over MH-97. Significant differences in 1000- grain weight were found among different irrigation treatments.He also reported non significant differences for TDM production by two cultivars. However TDM yield varied from 11.73 t ha^{-1} in *cv.* Inqalab-91 to 12.41 t ha^{-1} in *cv.* MH-97. Cultivar Inqalab-91 produced significantly higher grain yield than *cv.* MH-97 by 15.6 % in 1998-99 and 10.7 % in 1999-2000, respectively. Averaged over the two years a mean grain yield of 4007 kg ha^{-1} and 3554 kg ha^{-1} for Inqalab-91 and MH-97 was recorded, respectively.

MATERIALS AND METHODS

The field study was conducted during 2001-2002 and 2002-2003 growing seasons at the Agronomic Research Area, Postgraduate Agriculture Research Station (PARS), University of Agriculture, Faisalabad.The experiments were laid out in a split plot designe and treatments consisted of two wheat cultivars (C_1= Uqab-2000 and C_2=Chenab-2000) in main plots and nine levels of irrigation (I_0 = No irrigation, I_1 = Irrigation up to tillering, I_2= Irrigation at stem elongation, I_3= Irrigation from tillering to stem elongation, I_4= Irrigation from stem elongation to booting, I_5= Irrigation from booting to earing, I_6=Irrigation from booting to anthesis, I_7= Irrigation from tillering to booting and then at anthesis and I_8 = Irrigation throughout the season i.e.from crown root stage up to maturity including grain growth period) in the subplots. There were four replications, having a plot size of 1.8 m x 7.0 m. The crop was sown manually in 15 cm apart with the help of single row hand drill on November14 and 21, during 2001-2002 and 2002-2003, respectively, using a seed rate of 100 kg.ha^{-1} on a well prepared seed bed.All the fertilizer @ 120.0 kg N and 100.0 kg P_2O_5 ha^{-1} was applied to all the plots at the time of seedbed preparation.

Maximum potential soil moisture deficit (D) was used as a criterion for irrigation (French and Legg, 1979). Daily Penman's potential evapotranspiration (PET) was calculated by using standard programme of 'CROPWAT' developed by FAO (1992). The amount of water applied was equal to the difference between potential evapotranspiration (PET) and rainfall +irrigation in the previous week.

$D = \sum PET - \sum (I + R)$ Where **I** is irrigation and **R** is rainfall

The calculations assumed the soil to be at field capacity at sowing; and thereafter, on second and seventh December during 2001-2002 and 2002-2003 growing seasons respectively, a uniform irrigation of about 100 mm was applied to all the treatments. A measured quantity of water was applied by manual labor with the help of a fountain bucket fitted with a shower. At maturity, an area of 0.9m x 6.0m (5.4 m^2) from each plot was harvested at ground level and thrashed manually for the estimation of total biomass and grain yield per plot. This was converted into kilogram per hectare.The number of ear bearing tillers were counted from 1.0 m^2 area from each plot at random before harvest. Twenty plants were selected at random from each plot for the determination of various yield component.Harvest index (HI) was calculated as:

HI=Grain yield/ TDM*100

All sets of data were analysed statistically using the analysis of variance technique and the significance of treatment means was tested using the least significant difference (LSD) test at 5% probability (Steel and Torrie, 1984). The effect of irrigation levels was analyzed using orthogonal comparisons (Single degree of freedom contrasts) with the analysis of variance. The following planned comparisons were used to separate the means as suggested by Little and Hill (1978).

1) I_0 vs (I_1+---------+I_8) 4) I_3 vs I_6
2) I_3 vs (I_1+I_2) 5) (I_1+I_2+I_3+I_4+I_5) vs 3) (I_6+I_7)
3) I_6 vs (I_4+I_5) 6) I_7 vs I_8

RESULTS AND DISCUSSION

COMPONENTS OF YIELD

Number of ears m^{-2}

Cultivar differences in the number of ears m^{-2} were significantly affected in both the seasons (Table 1, 2). The range of ears for Chenab-2000 was 419-440 m^{-2}, where as for Uqab-2000 it ranged from 429-438 m^{-2}. Averaged over two years data, Uqab-2000 gave the highest number of ears at 434 m^{-2} as compared to Chenab-2000 which produced 429 ears m^{-2}. In both seasons, irrigated crop plants enhanced the number of productive tillers over unirrigated control treatment. Crop plants irrigated during early vegetative stage significantly reduced productive tiller as compared to plants irrigated thereafter. Significant effect of cultivar and irrigation at different growth stages on the number of tillers is in line with the previous work on wheat (Swati *et al.*, 1985; Sajjad, 2001). Interaction between cultivar and irrigation levels affecting the number of ears m^{-2} was significant in both the seasons (Table 3). Sharif (1999) reported 447 tillers m^{-2} in irrigated crop plants compared to no or less irrigated crops.

Table 1. Number and amount of irrigations plus rainfall (mm) for different irrigation treatments 2001- 02.

Date	I_0	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8
02-12-01	100	100	100	100	100	100	100	100	100
23-12-01	-	25	-	25	-	-	-	25	25
15-01-02	-	25	25	25	25	-	-	25	25
31-01-02	-	-	25	19	25	-	-	19	-
05-02-02	-	-	-	-	25	25	25	11	25
15-02-02	-	-	-	-	-	25	25	-	25
25-02-02	-	-	-	-	-	-	25	25	25
10-03-02	-	-	-	-	-	-	-	-	25
17-03-02	-	-	-	-	-	-	-	-	25
22-03-02	-	-	-	-	-	-	-	-	20
Sub total	100	150	150	169	175	150	175	205	295
Rainfall	11	11	11	11	11	11	11	11	11
Total	111	161	161	180	186	161	186	216	306
2002- 03									
Date	I_0	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8
07-12-02	100	100	100	100	100	100	100	100	100
29-12-02	-	25	-	25	-	-	-	25	25
16-01-03	-	22	25	25	25	-	-	25	25
08-02-03	-	-	25	20	25	-	-	20	20
23-03-03	-	-	-	-	-	-	-	-	25
02-04-03	-	-	-	-	-	-	-	-	25
08-04-03	-	-	-	-	-	-	-	-	25
Sub total	100	147	150	170	150	100	100	170	245
Rainfall	125	125	125	125	125	125	125	125	125
Total	225	272	275	295	275	225	225	295	370

Source: Ayub Agricultural Research Institute, Faisalabad, (Pakistan)

I_0 = No irrigation, I_1 = Irrigation up to tillering, I_2= Irrigation at stem elongation, I_3= Irrigation from tillering to stem elongation, I_4= Irrigation from stem elongation to booting, I_5= Irrigation from booting to earing, I_6=Irrigation from booting to anthesis, I_7= Irrigation from tillering to booting and then at anthesis and I_8 = Irrigation throughout the season i.e.from crown root stage up to maturity including grain growth period.

Number of spikelets ear^{-1}

On an average, Uqab-2000 and Chenab-2000 gave 16.81 and 17.22 spikelets ear^{-1}, respectively; however cultivar differences were nonsignificant in both the seasons (Table 2). Crop plants irrigated through the entire growth season (I_8) enhanced the number of spikelets over control (Nil treatments) by 38.5 % in 2001-2002 and 34.3 % in 2002-2003. Crop plants irrigated early in the growth season significantly reduced the number of spikelets ear^{-1} as compared to plants irrigated from earing to maturity (I_4, I_5, I_6, I_7) or throughout the season (I_8) in both the seasons.Similar effects of cultivar and irrigation on the number of spikelets ear^{-1} were also reported by others researchers (Sharif, 1999; Sajjad, 2001; Wajid, 2004).

Table 2. Effect of cultivar and irrigation levels on number of ears m^{-2}, number of spikelets ear^{-1} and number of grains ear^{-1}

Treatment	Number of ears m^{-2}			Number spikelets ear^{-1}			Number of Grains ear^{-1}		
Cultivar	2001-2	2001-3	Mean	2001-2	2001-3	Mean	2001-2	2001-3	Mean
C_1	438.28^{NS}	28.92 a	434	17.41^{NS}	16.20^{NS}	16.81	46.97 a	51.85^{NS}	49.41
C_2	439.58	418.78 b	429	17.55	16.89	17.22	43.63 b	53.59	48.61
LSD 5%	8.68	2.19		0.29	0.89		2.08	6.40	
I L									
I_0	398.75 e	376.50 g	388	14.46 f	14.76 d	14.61	34.08 f	44.31 c	39.19
I_1	445.00 c	428.12 d	437	16.58 e	14.97 d	15.77	41.05 e	46.94 c	44.00
I_2	429.38 d	15.75 e	423	16.76 de	15.94 c	16.35	43.84 d	48.62 c	46.23
I_3	463.87 b	439.50 c	452	17.47 cd	16.46 c	16.96	45.29 d	48.69 c	46.99
I_4	423.25 d	426.38 d	425	17.58 c	16.36 c	16.97	43.73 d	48.51 c	46.12
I_5	420.50 d	399.62 f	410	17.49 cd	16.51 c	17.00	44.42 d	55.76 b	50.09
I_6	402.13 e	414.0e	408	18.01 c	16.36 c	17.18	47.89 c	55.95 b	51.92
I_7	483.38 a	453.50 b	468	18.95 b	17.76 b	18.35	50.84 b	60.82 ab	55.83
I_8	484.12 a	461.25 a	473	20.03 a	19.83 a	19.93	56.54 a	64.88 a	60.71
LSD 5%	10.38	6.17		0.76	0.94		2.21	5.51	
Contrast									
I_0 vs I_1----+I_8	**	**		**	**		**	**	
I_3 vs (I_1+I_2)	NS	**		**	*		**	NS	
I_6 vs (I_4+I_5)	**	NS		NS	NS		**	NS	
I_3 vs I_6	**	**		NS	NS		*	*	
(I_1+I_2+I_3+I_4+I_5) vs (I_6+I_7)	**	**		**	**		**	**	
I_7 vs I_8	NS	*		**	**		**	NS	
Interaction	**	**		NS	NS		NS	NS	
Mean	438.93	423.85		17.48	16.55		45.30	52.72	

Means in a column not sharing a letter differ significantly at ($P \leq 0.05$) , NS = Non significant
*, ** = Significant at 1% and 5% respectively. IL= Irrigation levels

Number of grains ear^{-1}

Mean number of grains ear^{-1} was 49.41 in Uqab-2000 and 48.61 in Chenab-2000 with a range of 43.63 to 53.59, respectively (Table 2).Irrigations applied during vegetative growth stage (prior to earing) reduced the number of grains ear^{-1} as against to those of I_7 and I_8 treatments. Moisture stress at earing (I_7) had pronounced effect on grain number ear^{-1} in 2001-2002, because of dry season. Averaged over the two years the number of grains ear^{-1} varied from 39.19 to 60.71 grains ear^{-1} among different irrigation levels. Many workers reported similar number of grains spike^{-1} in wheat (Bajwa *et al*., 1993; Reddi and Reddi, 1995; Sharif, 1999; Sajjad, 2001). Wajid (2004) also reported 34 – 46 grains ear^{-1} among different irrigation treatments, working in similar conditions.

1000-grain weight:

Mean grain weight for cultivars was nonsignificant in both the years. It was 33.85g to 34.32g for Uqab-2000 Chenab-2000; respectively (Table-4).Dry season had conspicuously negative impact on mean grain weight. Irrigation during vegetative and reproductive stage including the grain growth period (I_8) increased mean grain weight 22.04 % to 104.45 % over unirrigated treatment. Generally crops receiving irrigation only earlier in the season reduced grain weight as compared to treatments receiving water after earing or throughout the seasons. The results corroborate the findings of others who also noted increased weight of grains with increased number of irrigations among various cultivars of wheat (Swati *et al.*, 1985; Bajwa *et al.*, 1993; Hussain *et al.*, 1997; Sajjad, 2001; Wajid, 2004).

Table 3. Interaction between cultivar and irrigation levels affecting number of ears m^{-2}, total dry matter and harvest index.

	Number of ears m^{-2}				Total dry matter (kg ha^{-1})				HI	
	2001-2002 Cultivar		2002-2003 Cultivar		2001-2002 Cultivar		2002-2003 Cultivar		2001-2002 Cultivar	
IL	C_1	C_2	C_1	C_2	C_1	C_2	C_1	C_2	C_1	C_2
I0	416.25 efg	381.25 i	381.25 j	371.75 k	10093 j	9144 k	13097 jk	12542 k	25.40 g	27.86 ef
I1	443.50 c	446.50 c	435.25 ef	421.00 g	14005 fg	13634 gh	14898 efg	13093 jk	26.20 fg	27.85 ef
I2	436.58 cd	422.25 def	429.00 fg	402.50 i	14352 ef	12269 i	13745 hij	13282 ij	26.53 eg	30.55 cd
I3	466.00 b	461.75 b	440.25 de	438.75 de	14954 d	14699 de	15338 e	14449 fgh	27.53 efg	31.22 bcd
I4	423.50 def	423.00 def	441.00 de	411.75 h	13981 eg	14468 def	15282 e	13889 hi	28.92 de	27.58 efg
I5	412.50 fgh	428.50 de	410.75 hi	388.50 j	14583 de	12620 i	15278 e	13889 hi	27.81 ef	32.83 abc
I6	406.00 gh	398.25 h	423.50 g	404.50 hi	14745 de	13310 h	16204 d	14262 gh	29.28 de	34.24 a
I7	476.00 b	490.75 a	445.75 cd	461.25 ab	15741 c	14977 d	17130 c	15130 ef	30.50 cd	33.06 ab
I8	464.25 b	504.00 a	453.50 bc	469.00 a	18981 a	17593 b	18796 a	18014 b	31.92 abc	34.02 a
LSD	=14.68		LSD =8.723		LSD =562.6		LSD =718.5		LSD= 2.37	

Means followed by the same letter do not differ significantly at ($P \leq 0.05$)
IL= Irrigation levels, C_1 =Uqab -2000, C2 =Chenab-2000, HI = Harvest index (%)

Total dry matter:

The cultivar Uqab-2000 significantly enhanced TDM yield by 7.0 % in 2001-2002 and 8.8 % in 2002-2003 over Chenab-2000 (Table 4).The crops irrigated throughout the growing season (I_8) enhanced TDM, at final harvest, compared to control (I_0, Nil) or partially irrigated treatments in both the seasons. Crop plants irrigated up to booting and thereafter were significantly superior in TDM production than the ones irrigated upto tillering, at sterm elongation only and from tillering to stem elongation (I_1, I_2, I_3). Interaction between cultivar and irigation levels effecting TDM yield was significant in both the seasons (Table 3).Sharif (1999) has also reported final TDM production, ranging from 12.4 t ha^{-1} to 14.2 t ha^{-1} among various cultivar and irrigation levels, working in similar agro-climatic conditions.

Grain yield:

Though cultivar differences in grain yield were non-significant yet it ranged from 4.34 t ha^{-1} to 4.47 t ha^{-1} in Uqab-2000 and Chenab-2000, respectively (Table 4).Fully irrigated (I_8) plants increased yield by 136.1% in 2001-2002 and 40.9% in 2002-2003 over control (I_0) treatmentCrop plants irrigated early in the season, i.e. upto tillerin , at stem elongation and from tillering to stem elongation significantly reduced grain yield than plants irrigated from tillering to booting and then at anthesis (I_7) and plants irrigated at all growth stages (I_8).Significantly greater grain yield in I_8 than I_7 indicated a prominent impact of irrigation during grain growth stage.There seems an increase in grain yield with an increase in the total dry matter and the number of grains per unit area.Hussain *et al.* (1997) compared wheat cultivars and concluded that grain yield of Inqalab-91 was the highest. Sharif (1999) also reached a similar conclusion. Results also confirmed that grain yield was increased with irrigation over non-irrigated or less irrigated treatment. These results substantiate the findings of other workers who also noted similar effects of irrigation on grain yield in wheat (Sharif, 1999; Qadir *et al.*1999; Kuixiang *et al.*, 1996; Wajid , 2004; Hussain *et al.*, 2004).In both the seasons, mean grain weight tended to be closely correlated ($r = 0.904^{**}$) with grain yield. Most yield components such as number of tillers m^{-2}, number of seeds $spike^{-1}$ and harvest index were highly positively and significantly correlated with grain yield. Both HI and plant height were only correlated during 2001-2002 season (Table 5). These results are in line with the work of Wajid (2004) who also noted significant correlation between grain yield and its components.

Table 4. Effect of cultivar and irrigation levels on total dry matter (TDM) , 1000 grain weight and grain yield.

	TDM			1000 grain weight (g)			Grain yield (kg ha^{-1})		
Treatment	2001-2	2001-3	Mean	2001-2	2001-3	Mean	2001-2	2001-3	Mean
Cultivar									
C_1=Uqab-2000	14604a	15530a	15067	28.56^{NS}	39.15^{NS}	33.85	4158^{NS}	4526^{NS}	4342
C_2=Chenab-2000	13635b	14282b	13959	28.25	40.39	34.32	4255	4684	4469
LSD 5%	76.78	18.40		1.52	3.30		182.37	338.77	
I L									
I_0	9618 h	12819 f	11219	20.42 f	36.25 d	28.33	2548 f	3988 e	3268
I_1	13819 ef	13995 e	13907	24.35 e	37.27 d	30.81	3730 e	4169 e	3950
I_2	13310 g	13514 e	13412	25.03 de	37.67 d	31.35	3781 e	4203 de	3992
I_3	14826 c	14894 cd	14860	27.30 cd	37.33 d	32.32	4357 c	4567 c	4662
I_4	14225 d	14586d	14406	25.55de	40.32 c	32.93	4015 d	4532cd	4274
I_5	13602 fg	14583 d	14093	25.39 de	40.69 bc	32.04	4099 d	4686 bc	4393
I_6	14028 de	15236 c	14732	28.23 c	42.14 b	35.18	4436 c	4973 b	4694
I_7	15359 b	16130 b	15745	37.58 b	41.90 bc	39.79	4874 b	4733 bc	4803
I_8	18287 a	18405 a	18346	41.75 a	44.24 a	43.00	6021 a	5618 a	5819
LSD 5%	397.9	508.0		2.27	1.71		215.63	334.75	
Contrast									
I_0 vs I_1----+I_8	**	**		**	**		**	**	
I_3 vs (I_1+I_2)	**	NS		**	NS		**	NS	
I_6 vs (I_4+I_5)	NS	**		**	*		**	*	
I_3 vs I_6	**	NS		NS	**		NS	*	
(I_1+I_2+I_3+I_4+I_5) vs (I_6+I_7)	**	**		**	**		**	**	
I_7 vs I_8	**	**		**	*		**	**	
Interaction	**	*		NS	NS		NS	NS	
Mean	14119	14907		28.40	39.77		4207	4605	

Means in a column not sharing a letter differ significantly at ($P \leq 0.05$) , NS = Non significant
*, ** = Significant at 1% and 5% respectively IL= Irrigation levels, I_0 = No irrigation

Harvest index (%):

Chenab-2000 gave higher harvest index by 9.8 % (31.02 vs 28.24) in 2001-2002 and 12.6 % (32.85 vs 29.17) in 2002-2003 over Uqab-2000 (Table 6).

Irrigation treatments also significantly increased HI over control (Nil) treatment in 2001-2002 but not in 2002-2003 season. Differences in HI between I_6 (irrigation from booting to anthesis), I_7 (irrigation from tillering to booting and then at anthesis) and I_8 (irrigation throughout) treatments were, however, at par. The HI between early irrigation (I_1 and I_2) treatments was also statistically at par. Overall, mean harvest index varied from 29.63 % in 2001-2002 to 31.0 % in 2002-2003, respectively. Interaction between cultivar and irrigation levels (Table 3) showed that irrigation applications in the later part of growth enhanced HI, and this response was higher in Chenab-2000 as compared to Uqab-2000. Results showed that water stress of different durations and at different stages reduced HI, irrespective of cultivars. Similar results were reported by others (Boogaard et al., 1996; Sharif, 1999; Sajjad, 2001; Wajid, 2004).

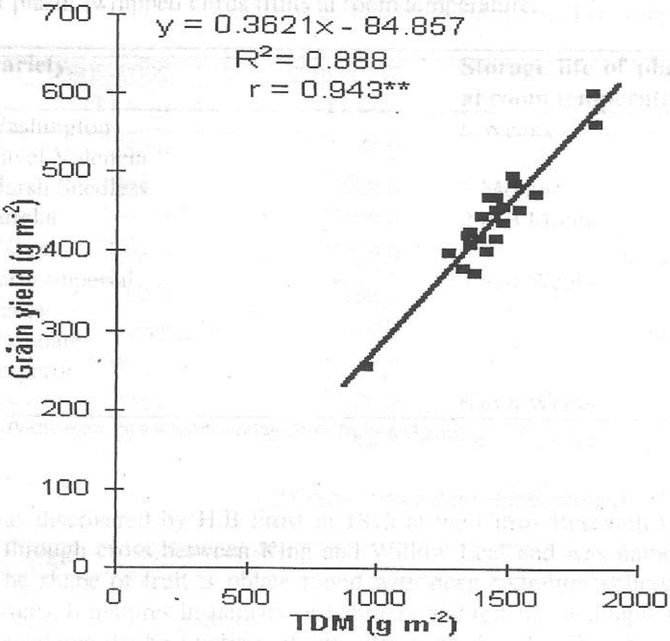

Fig. 4. Relationship between grain yield and TDM for pooled data.

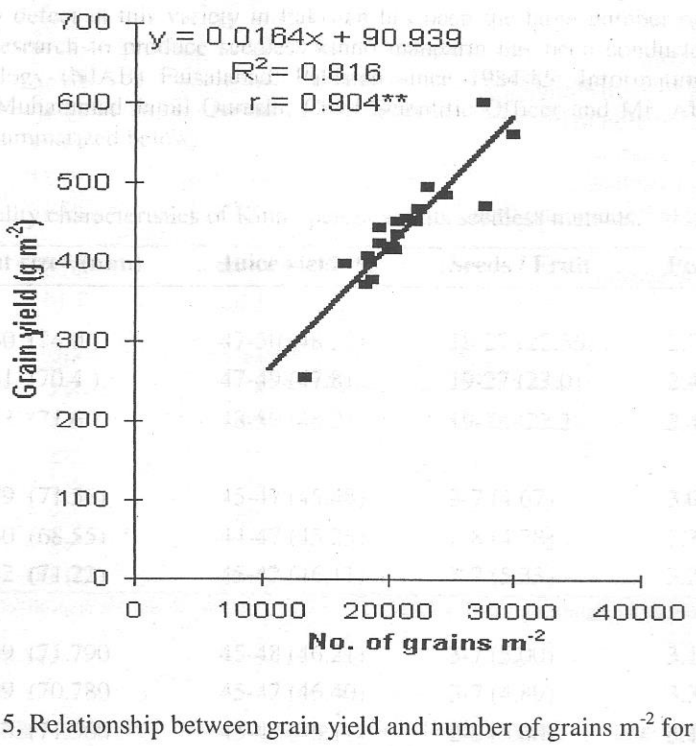

Fig. 5, Relationship between grain yield and number of grains m^{-2} for pooled data.

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Table 5. Correlation coefficient (r) between grain yield and its attributes.

Variable	2001-2002 (n = 11)	2002-2003 (n = 11)	Pooled (n = 22)
Grain yield vs ears m^{-2}	0.743**	0.623*	0.547**
Grain yield vs spikelets ear^{-1}	0.936**	0.869**	0.705**
Grain yield vs grains ear^{-1}	0.977**	0.902**	0.878**
Grain yield vs 1000-grain weight	0.927**	0.899**	0.784**
Grain yield vs grains m^{-2}	0.962**	0.887**	0.904**
Grain yield vs total dry matter	0.966**	0.915**	0.943**
Grain yield vs harvest index	0.821**	0.220NS	0.707**
Grain yield vs plant height	0.951**	0.399NS	0.819**

*, ** = Significant at 5% and 1%, respectively; NS = Non-significant.

Table 6. Effect of cultivar and irrigation levels on harvest index (%).

Treatment	2001-2002	2002-2003	Mean
Cultivar			
C_1 = Uqab-2000	28.24 b	29.17 b	28.70
C_2 = Chenab-2000	31.02 a	32.85 a	31.93
LSD 5%	1.11	2.27	
Irrigation Levels			
I_0 = No-irrigation	26.63 f	31.14NS	28.88
I_1 = Irrigation upto tillering	27.03 ef	29.92	28.47
I_2 = Irrigation at stem elongation	28.54 de	31.15	29.84
I_3 = Irrigation from tillering to stem elongation	29.40 cd	30.70	30.05
I_4 = Irrigation from stem elongation to booting	28.25 def	31.19	29.72
I_5 = Irrigation from booting to earing	30.32 bc	32.28	31.30
I_6 = Irrigation from booting to anthesis	31.77 ab	32.71	32.24
I_7 = Irrigation from tillering to booting and then At anthesis	31.78 ab	29.48	30.63
I_8 = irrigation throughout the season	32.97 a	30.50	31.73
LSD 5%	1.68	2.14	
Contrast			
I_0 vs I_1----+I_8	**	NS	
I_3 vs (I_1+I_2)	*	NS	
I_6 vs (I_4+I_5)	**	NS	
I_3 vs I_6	**	NS	
(I_1+I_2+I_3+I_4+I_5) vs (I_6+I_7)	**	NS	
I_7 vs I_8	NS	NS	
Interaction	*	NS	
Mean	29.63	31.00	

Means in a column not sharing a letter differ significantly at ($P \leq 0.05$); *, ** = Significant at 1% and 5% respectively; NS = Non significant.

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